OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Semester 2 Examinations 2023-2024

Course Instance Code(s)	4BCT, 3BP, 4BP, 1OA
Exam(s)	BSc in Computer Science & Information Technology BE in Electronic & Computer Engineering
Module Code(s)	CT414
Module(s)	Distributed Systems
Paper No.	1
External Examiner(s)	Dr. R. Trestian
Internal Examiner(s)	Prof. M. Madden ***Dr. D. Chambers

Instructions: Answer any 4 questions.
All questions carry equal marks.

Duration	2 hours
No. of Pages	4
Department(s)	School of Computer Science
Course Co-ordinator(s)	Dr Colm O'Riordan

Requirements:

Release in Exam Venue	Yes	X	No	
MCQ Answersheet	Yes		No	X
Handout	None			
Statistical/ Log Tables	None			
Cambridge Tables	None			
Graph Paper	None			
Log Graph Paper	None			
Other Materials	None			
Graphic material in colour	Yes		No	X

1. You are required to implement an Internet based College Course application system for the University using Java RMI. The server allows a client to login and retrieve an Application Form object that will then be completed on the client side. The client can then submit the completed Application Form object back to the server for validation and processing. The answer should include full source code for the following Java interfaces and classes:

   a: Write a Java interface called *CourseServer* that provides remote methods for user login, based on a username and password, downloading an Application Form and submitting a completed Application Form. The login method returns a token, that is valid for some time period, that must be passed to the other two server methods as a session identifier. The methods to download and upload an Application Form object should use the interface type *ApplicationForm* as described in part b below. Include any required remote method exceptions. 4 MARKS

   b: Write a Java interface called *ApplicationForm* that provides methods for the retrieval and answering of the kind of questions you would expect to find on an application form used to apply for a third level college course. It should include methods to allow the following information about the applicant to be included in a completed application form: name, address, email and contact number of the applicant. It should also have a method to include a personal statement e.g. this could be used to include additional details about the applicant and a summary of their existing qualifications or results. Include any required method exceptions. 4 MARKS

   c: Write the Java server code, and the *CourseServer* implementation methods, required to initialise the server and register an instance of the *CourseServer* implementation class in the RMI Registry. A single valid username and password can be hardcoded into the server for the purposes of implementing the login method. You **do not** need to provide an implementation class for the *ApplicationForm* interface, you can assume that this has already been implemented in a class called *AppForm-v1*. The *CourseServer* implementation method to download an ApplicationForm therefore just needs to return an instance of the *AppForm-v1* class. The *CourseServer* implementation method to upload a completed *ApplicationForm* should just save the completed form to a file. You **do not** need to provide implementations for any exception classes. 8 MARKS

   d: Write the Java code for a simple command line client program that will interact with the server as follows: (i) Login to the server. (ii) Download an Application Form object. (iii) Call methods on the Application Form, as required to complete the form. (iv) Submit the completed Application Form back to the sever. 6 MARKS

   e: What is the main advantage of defining *ApplicationForm* as an interface type and then using this in the remote methods? 3 MARKS

2.a: Write a short essay, approximately 300 words, on **one** of the following topics. The essay should include a full description of the topic and also discuss its advantages, disadvantages and competitor technologies (if applicable)

i. Enterprise Java Beans
ii. Cloud Computing
iii. Web Services 15 MARKS

b: Assume that you have been contracted by a large multinational company to develop an enterprise class client / server application that may be accessed by a large number of clients concurrently. You will therefore need to employ some form of load balancing in the design of the application. What type of load balancing systems would you recommend? In this context, describe both low-level and high-level load balancing mechanisms. Also provide some examples of real world systems or services that use the high-level load balancing mechanisms you have recommended. 10 MARKS

3.a: What is unique about Node.js when compared to other server technologies like e.g. the Apache web server? How can a Node.js application efficiently handle reading and writing very large files e.g. where it is trying to make a copy of a file? 4 MARKS

b: Explain briefly the purpose of the **npm** utility. Describe the purpose and the effect of running the following command:

npm init 4 MARKS

c: In the context of implementing a web server type application in Node.js what are the advantages of using Node.js with the Express framework? Write the Node.js code to implement a simple web server, using the Express framework, that responds with a simple text message when the URI /**main** is invoked. 7 MARKS

d: You are required to design an application that allows programmers to submit votes for their favourite programming language. Describe a suitable architecture and design for a distributed application that uses the Java Messaging Service (JMS) to submit these votes as messages to a queue. Another related application should similarly use JMS to consume these messages from the queue and tally votes. Full Java source code is not required but your answer should provide a full description of how the JMS would be used within the application, the description should include code samples or pseudo-code for the JMS related parts of the application. Also describe how the application might use the Java Naming and Directory Interface (JNDI) as part of this solution. 10 MARKS

4 a: Explain the role of the Proxmox Virtualisation Environment. In this context, what is the difference between a Virtual Machine and a Container and which of these is faster to migrate to a different host on a Proxmox cluster? 6 MARKS

b: How is it possible to run Virtual Machines at near native speed using Kernel-based Virtual Machine (KVM) infrastructure? 4 MARKS

c: What is the purpose of the Ceph storage platform and what advantages does it have over traditional RAID based storage? Describe the high level architecture and the main components of the Ceph storage platform. Include in this description details about the following items: Ceph Network, Object Storage Devices and Ceph Pools. 8 MARKS

d: What are the advantages of grouping physical servers into a cluster? How does a Proxmox cluster implement High Availability and what might cause a Virtual Machine migration to fail? 7 MARKS

5.a: What types of services are typically available from commercial Cloud Computing providers? Provide some examples of each of these services in your answer. 5 MARKS

b: Suppose you work for a social media company that collects a lot of very large data sets e.g. web logs or other application related data that needs to be stored and analysed. Also assume that the company has access to large scale computing resources based in multiple data centres. Explain how using the Apache Hadoop Distributed File System (HDFS) and its related facilities might help in solving the storage and analysis requirements of the company. Your answer should include a high-level architectural diagram outlining how the HDFS is typically organised in terms of data block storage. Discuss the specific advantages of this approach over using traditional database systems for this type of data. 10 MARKS

c: Describe in detail the MapReduce programming model. Outline the architecture for a MapReduce application that could be used to index a large number of text files by the individual words present in each file. Full source code for the application is not required but your answer should describe the data structures that would need to be used and also clearly explain the purpose and functionality of the map() and reduce() functions in solving this problem, the explanation should include related code samples or pseudo-code for these functions. What kind of threading model makes most sense in terms of running the map() and reduce() functions. 10 MARKS